APPENDIX J – RBC CALCULATION METHODOLOGIES

FINAL FEASIBILITY STUDY REPORT
CASMALIA RESOURCES SUPERFUND SITE
CASMALIA, CALIFORNIA
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LIST OF ACRONYMS

ADD	Average Daily Dose
BAF	bioaccumulation factor
COC	chemical of concern
Eco RBC	Ecological risk-based concentration
ERA	Ecological Risk Assessment
FS	Feasibility Study
FS Report	Feasibility Study Report
HHRA	Human Health Risk Assessment
HQ	hazard quotient
kg	kilogram(s)
kg soil/day	kilograms soil per day
kg soil/kg tissue	kilogram soil per kilogram of tissue
kg tissue/day	kilograms tissue per day
LADD	Lifetime Average Daily Dose
LOAEL	lowest observed adverse effect level
MCPP	methylchlorophenoxypropionic acid
mg	milligrams
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram of body weight per day
NCP	National Contingency Plan
NOAEL	no observed adverse effect level
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
PSCT	Perimeter Source Control Trench
RBCs	risk-based concentrations
RCRA	Resource Conservation and Recovery Act
RI Report	Remedial Investigation Report
(the) site	Casmalia Resources Superfund Site
SVOC	semi-volatile organic compound
TCE	trichloroethene
TRV	toxicity reference value
UCL	upper confidence limit
VOCs	volatile organic compounds
WCSA	West Canyon Spray Area

1 INTRODUCTION

Risk-based concentrations (RBCs) for the protection of human health and ecological receptors were derived for the Casmalia Resources Superfund Site (site) to be used as human health and ecological site-specific soil threshold levels to define remedial alternatives and specify impacted locations or areas for remedial evaluation.

The chemicals of concern (COCs) are listed as “risk-driving chemicals” in Table 8-4 of the main *Feasibility Study Report* (FS Report). These COCs are listed by Feasibility Study (FS) Area and were identified primarily based on the results of the ecological risk assessment (ERA), as potential risk at the site is driven primarily by predicted effects to ecological receptors. The ERA (Tiers 1 and 2) was presented as Appendix U of the *Final Remedial Investigation Report* (RI Report) (CSC 2011). While there are some human health risks, for the most part, the acceptable soil concentrations are set by ecological concerns. The human health risk assessment (HHRA) was presented as Appendix T of the RI Report (CSC 2011). The COCs listed as risk-driving chemicals in Table 8-4 of the main FS Report are derived from the Tier 2 ERA for those study areas where the Tier 2 evaluation was performed, while in other study areas, the Tier 1 COCs are listed.

In the RI Report (CSC 2011), the presence of elevated COC concentrations and the results of the ERA and HHRA were used to identify chemicals that contributed significantly to site risk in surface and shallow soil (0 to 5.5 feet below ground surface [bgs]) and in sediment (0 to 0.5 foot below sediment surface). Chemicals of l concern were identified as potential risk drivers for ecological and human health based on the results of the quantitative risk estimates, the weight-of-evidence provided in the ERA and HHRA, and the planned remedies as part of the United States Environmental Protection Agency- (USEPA-) approved closure plan for some of the study areas (Central Drainage Area [CDA], Burial Trench Area [BTA], Maintenance Shed Area [MSA], Liquid Treatment Area [LTA], and all the ponds [A-Series, RCA Pond, Pond A-5, Pond 18, and Pond 13]). These select COCs are referred to as risk-driving chemicals (RDCs) in this appendix and are a subset of the COCs listed as risk-driving chemicals in Table 8-4 of the main FS Report.

RDCs were identified based on potential unacceptable risk to ecological and human receptors exposed to site media in study areas with no planned remedy, which include Resource Conservation and Recovery Act (RCRA) Canyon, West Canyon Spray Area, Administrative Building Area, Former Ponds and Pads South of the Perimeter Source Control Trench (PSCT), and Remaining On-site Areas.

The approach used in to develop ecological RBCs protective of ecological receptors (Section 2.0) and human health RBCs protective of human receptors (Section 3.0) are described in this appendix and summarized in Section 8.6 of the main FS Report.

2 ECOLOGICAL RISK-BASED CONCENTRATIONS

RDCs were identified based on potential unacceptable risk to ecological receptors based on the quantitative risk estimates (Tier 1 and Tier 2 ERA), the weight-of-evidence provided in the ERA, and the planned remedy for some of the study areas. Ecological RBCs (Eco RBCs) for site media were developed based on ecological exposure and effects assumptions using the standard hazard quotient (HQ) model for assessing risk to ecological receptors (USEPA 1997). The input parameters for the Eco RBC equation include body weight, soil and food ingestion rates, site use factors, bioaccumulation factors (BAFs), screening values, and toxicity reference values (TRVs). This section describes the basis of the selection of the ecological RDCs and the approach and methods used to derive Eco RBCs using these inputs.

2.1 Conclusions of the Ecological Risk Assessment

Based on the Tier 1 ERA and Tier 2 ERA for the site and the updated evaluation for barium toxicity (Appendix C of the main FS Report), the following RDCs were identified in surface soil (0 to 0.5 feet bgs) and surface and shallow soil (0 to 5.5 feet bgs):

Study Area	**RDCs[1] in Surface Soil (Based on Terrestrial Birds, Soil Invertebrates, and Plants)**	
	Tier 1 ERA	**Tier 2 ERA[2]**
RCRA Canyon Area	Cadmium, Chromium, Copper, Lead, and Zinc	Chromium, Copper, and Zinc
WCSA	Cadmium, Chromium, Copper, Lead, and Zinc	Chromium, Copper, and Zinc
Administration Building Area	None	None
Roadway Area	Chromium, Copper, Lead, Zinc, and Aroclor 1260	None
Remaining On-site Area	None	None
Former Ponds and Pads Areas	Total PCBs	None

-- Exposure area not evaluated in Tier 2
PCB = polychlorinated biphenyl
[1] = RDCs selected based on the criteria described in Sections 6.2 and 12.2 of Appendix U of the RI Report (CSC 2011).
[2] = RDCs based on terrestrial birds only.

Study Area	RDCs[1] in Shallow Soil (Based on Terrestrial Mammals, Soil Invertebrates, and Plants)	
	Tier 1 ERA	Tier 2 ERA[2]
RCRA Canyon Area	Cadmium, Chromium, Copper, and Zinc	None
WCSA	Cadmium, Chromium, Copper, and Zinc	None
Administration Building Area	None	None
Roadway Area	Chromium, Copper, and Zinc	None
Remaining On-site Area	None	None
Former Ponds and Pads	Chromium and Total PCBs	None

-- Exposure area not evaluated in Tier 2
[1] = RDCs selected based on the criteria described in Sections 6.2 and 12.2 of Appendix U of the RI Report (CSC 2011).
[2] = Risk drivers based on terrestrial mammals only.

No unacceptable risks are predicted for the American badger, a special-status species, or other burrowing receptor populations.

For sediment invertebrates, aquatic life, aquatic plants, amphibians, and aquatic wildlife, although there are potential unacceptable risks from some COCs (mostly metals) in sediment and surface water in the ponds, no RDCs were identified based on the weight-of-evidence in the Tier 1 ERA. All of the ponds (A-Series, RCA Pond, Pond A-5, Pond 18, and Pond 13) will have a planned remedy as part of the USEPA-approved closure plan for the site and will be backfilled/graded to prevent accumulation of water, and therefore, the ponds will be unavailable as a pathway for aquatic receptors, essentially eliminating the potential for adverse effects to aquatic receptors.

For sediment invertebrates, aquatic life, aquatic plants, amphibians, and aquatic wildlife, although there are potential unacceptable risks from some COCs (mostly metals) in sediment and surface water in the off-site drainages, no risk drivers were identified based on the weight-of-evidence in the Tier 1 ERA. Off-site drainages do not receive any stormwater runoff from the Site. The containment of surface-water runoff within the site boundaries has effectively prohibited the off-site release of COC-bearing stormwater from on-site disposal areas into off-site areas. Therefore, any potential risks to aquatic receptors from these drainages are not considered site-related.

Based on the Tier 1 ERA, the seeps are currently dry and on-site facilities (i.e., Sump 9B and Road Sump) are in place to control these seeps. Therefore, on-site seeps are not expected to be sources of exposure to amphibians, aquatic life, or aquatic plants.

Based on the Tier 1 ERA, chemicals in surface water from RCRA Canyon runoff that indicate potential unacceptable risk to aquatic ecological communities and amphibians include:

Chemical	Aquatic Life	Amphibians	Aquatic Plants
Arsenic	X	X	X
Barium	X	X	--
Beryllium	--	X	--
Cadmium	X	X	X
Chromium	--	X	--
Lead	--	X	--

Chemical	Aquatic Life	Amphibians	Aquatic Plants
Manganese	--	X	--
Mercury	--	X	--
Molybdenum	--	X	--
Nickel	--	X	X
Selenium	X	X	X
Thallium	--	X	--
Vanadium	X	X	--
Zinc	--	X	--
Benzo(b)fluoranthene	X	--	--
Ethylene glycol	X	--	--

X = indicates potential unacceptable risk
-- = Not applicable for receptor/chemical

Risks to amphibians for RCRA Canyon runoff were estimated based on a conservative scenario. This scenario evaluated the potential risk to aquatic receptors under the hypothetical scenario that water pools in RCRA Canyon, which, based on site observations, does not occur under current site conditions. For amphibians, exceedance of the no effects-based screening levels is cause for concern. Rather than providing further evaluation of these cases in the ERA, the screening results can be relied on for future management decisions and/or additional evaluation of amphibian risks may be conducted, as warranted, when developing appropriate remedial alternatives.

Based on the conclusions of the ERA, the following COCs[1] were considered RDCs for terrestrial ecological receptors:

- Chromium
- Copper
- Zinc

2.2 Receptor Selection

Target HQs or concentrations used in the estimation of Eco RBCs are considered protective of ecological communities (plants and soil invertebrates) and wildlife (mammals and birds) populations. The Eco RBCs for surface soils (0 to 0.5 foot bgs) were based on protection of invertebrate and bird populations. Eco RBCs for surface and shallow soils (0 to 5.5 feet bgs) are based on the protection of plants and mammal populations.

The ecological receptors considered in the development of Eco RBCs are the same as those evaluated in the ERA (CSC 2011) and include:

- Surface soil Eco RBCs
    - o Soil invertebrates
    - o Terrestrial birds (herbivorous and invertivorous Western meadowlark)
- Surface and shallow soil Eco RBCs

[1] Barium was also identified as an RDC in the ERA (CSC 2011). However, upon further evaluation of the potential for toxicity of the form of barium expected to be at the site, barium was excluded as an RDC. Details are provided in Appendix C of the FS Report.

- o Plants
- o Terrestrial mammals (herbivorous California vole, invertivorous ornate shrew, and carnivorous striped skunk)
- o Special status, deep burrowing receptor (American badger)

2.3 Toxicity Values

For wildlife, the target TRVs were based on the lowest observed adverse effect level (LOAEL)/high TRV-based HQ of 1. The LOAELs were available or developed in the ERA (CSC 2011) for all the RDCs and are presented in Attachment J-1.

As there were no unacceptable risks to special status wildlife species (i.e., American badger), the no observed adverse effects level (NOAEL)/low TRV values for wildlife were not used in the Eco RBC calculations.

Although no unacceptable risks were identified for terrestrial ecological communities (plants and soil invertebrates), the USEPA requested a presentation of the Eco RBCs for the RDCs for all soil receptors (i.e., soil invertebrates, plants, terrestrial mammals, terrestrial birds, and the American badger). For the American badger, chromium, copper, and zinc were not identified as COPECs in the ERA (CSC 2011), because only those COPECs with maximum detected concentrations in the 0 to 10 feet bgs interval that were greater than maximum concentrations in the 0 to 5 feet bgs interval were selected as deep soil COPECs and evaluated further for deep burrowing receptors (the badger). Chromium, copper, and zinc were only detected at concentrations below background in the 5.5 to 10 feet bgs interval, and therefore, Eco RBCs protective of the American badger are not needed. Therefore, the methodology to calculating Eco RBCs, as described below, include all terrestrial receptors except the American badger.

2.4 Ecological Risk-Based Concentration Calculation Methodology

Eco RBCs were developed by back-calculation of the standard USEPA (1997) HQ equation to estimate soil/sediment concentrations based on a target HQ of 1. The model used to solve for Eco RBCs is as follows:

Ecological Communities:

$$HQ = \frac{C_{soil}}{SV} = 1$$

Where:

HQ	=	hazard quotient (unitless); set at a target value of 1
C_{soil}	=	concentration of chemical in soil (milligrams per kilogram [mg/kg]); exposure point concentrations (EPCs; based on the 95 percent upper confidence level [95 percent UCL] on the mean were used, if available, otherwise the maximum detected concentrations were used)
SV	=	screening value (mg/kg)

Wildlife:

$$HQ = \frac{Dose}{TRV} = \frac{(C_{soil} \times SIR) + (C_{tissue} \times FIR) \times AUF}{TRV \times BW} = \frac{(C_{soil} \times SIR) + (C_{soil} \times BAF \times FIR) \times AUF}{TRV \times BW} = 1$$

Where:

Dose	=	exposure dose (in mg/kg body weight per day [mg/kg-day])
HQ	=	hazard quotient (unitless); set at a target value of 1
TRV	=	toxicity reference value (mg/kg-day)
C_{soil}	=	concentration of chemical in soil (mg/kg soil); EPCs based on the 95% UCL on the mean were used, if available, otherwise the maximum detected concentrations were used
SIR	=	soil ingestion rate (kilograms soil per day [kg soil/day])
C_{tissue}	=	concentration of chemical in biota or tissue (mg/kg tissue)
FIR	=	food or biota ingestion rate (kilograms tissue per day [kg tissue/day])
BW	=	body weight of receptor (kilograms [kg])
BAF	=	bioaccumulation factor or regression for media-to-biota uptake (kilogram tissue per kilogram soil [kg soil/kg tissue])
AUF	=	area use factor (unitless); represents the fraction of the exposure area for the receptor represented by the area of contamination generally calculated by dividing the area of contamination by the home or foraging range of the receptor; assumed to be 1

The input parameters for terrestrial wildlife used to estimate the dose for the RDCs are those presented in the ERA (CSC 2011) and also presented in Attachment J-1 of this appendix. These include exposure parameters, BAFs, and TRVs. The EPCs used in the derivation of Eco RBCs are presented in Table J-1.

For the site, HQs were estimated and reported in the ERA (CSC 2011). Ecological RDCs were identified if: (1) chemical NOAEL/low TRV HQ greater than 10 or LOAEL/high TRV HQ greater than 1, including additional weight-of-evidence for wildlife or (2) chemical HQ greater than 2, including additional weight-of-evidence for ecological communities. Following this criteria, ecological RDCs include only three metals (chromium, copper, and zinc) based on the Tier 2 ERA. Although some organics were RDCs based on the Tier 1 ERA, none were identified as RDCs in the Tier 2 ERA, and therefore, Eco RBCs were not calculated for these organics.

As quantitative forward risk calculations were already completed in the ERA, generating HQs for ecological receptors, a simplified method was used to develop Eco RBCs incorporating the equations presented above. RBCs for each RDC were calculated using the following equation:

$$RBCi = \frac{C_{soil}i}{HQi}$$

Where:

HQi	=	hazard quotient (unitless) for chemical “i”

$C_{soil}i$	=	concentration of chemical in soil (mg/kg soil); EPCs based on the 95% UCL on the mean were used, if available, otherwise the maximum detected concentrations were used.
RBCi	=	risk-based concentration (mg/kg)

A stepwise approach was used in deriving Eco RBCs using the equation above:

1. The study areas with planned remedy were identified and excluded from RBC derivation. Therefore, the CDA, BTA, MSA, LTA, and all the ponds were not included in the derivation of Eco RBCs.
2. The highest HQs based on the target toxicity values for each RDC and the study area were identified (i.e., LOAEL/high TRV-based HQ greater than 1 and/or NOAEL/low TRV-based HQ greater than 10 for terrestrial wildlife).
3. The soil EPCs that were used in the risk calculations for the receptor and study area, identified in Step 1, were identified for this step (i.e., surface soil [0 to 0.5 foot bgs] for birds and soil invertebrates and surface and shallow soil [0 to 5.5 feet bgs] for mammals).
4. The soil EPC for each RDC (Step 3) was divided by the highest HQ (Step 2) to generate an Eco RBC for that RDC. For ecological communities, the screening values were the Eco RBCs. These generate RBCs equivalent to target HQ of 1.

Selecting the highest HQ for the different exposure depths confirms that the most sensitive receptor is selected and would be protective of all the ecological receptors at the site. Surface soil Eco RBCs would be protective of soil invertebrates and terrestrial birds exposed to surface soil (0 to 0.5 foot bgs) and surface and shallow soil Eco RBCs would be protective of plants and terrestrial mammals exposed to surface and shallow soil (0 to 5.5 feet bgs). However, as requested by the USEPA (2012), Eco RBCs for all the terrestrial receptors, except the American badger as described above, for the RDCs were also calculated as presented in Table J-1. This provides a range of values across appropriate receptors for making management decisions. Examples of the Eco RBC calculations are described below.

2.5 Examples of Eco RBC Calculations

The following are examples of Eco RBC calculations based on following the steps in Section 2.2.

Surface Soil Eco RBCs

For ecological communities, the screening values for the receptors are the Eco RBCs. Using chromium as an example, surface soil Eco RBC, based on soil invertebrates, was calculated as follows (also presented in Table J-1):

1. Based on the results of the Tier 1 ERA, the highest HQ for soil invertebrates exposed to chromium in surface soil (0 to 0.5 foot bgs) in the study areas with no planned remedy was a value of 1,477 in the West Canyon Spray Area.
2. The surface soil EPC for chromium in the West Canyon Spray Area is 591 mg/kg.
3. Dividing the surface soil EPC of 591 mg/kg by the HQ of 1,477 yields an RBC of 0.4 mg/kg (i.e., the chromium screening value for soil invertebrates).

Similarly for plants, using chromium as an example, surface and shallow soil Eco RBC, based on plants, was calculated as follows (also presented in Table J-1):

1. Based on the results of the Tier 1 ERA, the highest HQ for plants exposed to chromium in surface soil (0 to 5.5 feet bgs) in the study areas with no planned remedy was a value of 206 in the West Canyon Spray Area.
2. The surface soil EPC for chromium in the West Canyon Spray Area is 206 mg/kg.
3. Dividing the surface soil EPC of 206 mg/kg by the HQ of 206 yields an RBC of 1 mg/kg (i.e., the chromium screening value for plants).

For terrestrial birds, using copper as an example, surface soil Eco RBC, based on the invertivorous Western meadowlark, was calculated as follows (also presented in Table J-1):

1. Based on the results of the Tier 2 ERA, the highest LOAEL/high TRV-based HQ for all the terrestrial birds exposed to copper in surface soil (0 to 0.5 foot bgs) in the study areas with no planned remedy was a value of 18 for the invertivorous Western meadowlark from the West Canyon Spray Area (LOAEL/high TRV-based HQs were also greater than 1 in RCRA Canyon and the Roadway Area). Note that HQs were estimated using the input parameters provided in Attachment J-1.
2. The surface soil EPC for copper in the West Canyon Spray Area is 461 mg/kg.
3. Dividing the surface soil EPC of 461 mg/kg by the HQ of 18 yields an RBC of 25.5 mg/kg.

For terrestrial mammals, using zinc as an example, subsurface soil Eco RBC, based on the ornate shrew, was calculated as follows (also presented in Table J-1):

1. Based on the results of the Tier 2 ERA, the LOAEL/high TRV-based HQs were all less than 1; however, the highest NOAEL/low TRV-based HQ for all the terrestrial mammals exposed to zinc in surface and shallow soil (0 to 5.5 feet bgs) in the study areas with no planned remedy was a value of 21 for the ornate shrew from RCRA Canyon Area (the NOAEL/low TRV-based HQs were also greater than 10 in the West Canyon Spray Area). The LOAEL/high TRV-based HQ for the ornate shrew at RCRA Canyon Area is 0.5. Note that HQs were estimated using the input parameters provided in Attachment J-1.
2. The surface and shallow soil EPC for zinc in RCRA Canyon Area is 176 mg/kg.
3. Dividing the surface and shallow soil EPC of 176 mg/kg by the HQ of 0.5 yields an RBC of 353 mg/kg.

2.6 Summary of the Ecological Risk-Based Concentrations

The Eco RBCs for all the terrestrial receptors potentially exposed to soil in the study areas with no planned remedy are presented in Table J-1. The Eco RBC selected for surface and shallow soil (0 to 5.5 feet bgs) based on mammals are highlighted in blue in Table J-1, and the Eco RBC selected for surface soil (0 to 0.5 foot bgs) based on birds are highlighted in green in Table J-1.

These selected Eco RBCs are considered protective of ecological receptors potentially exposed to RDCs in site media.

3 HUMAN HEALTH RISK-BASED CONCENTRATIONS

This section presents the methodology and results for the calculation of human health RBCs (HH RBCs) for RDCs identified for soil. Human health RBCs were developed for the human health RDCs based on the results of the HHRA (CSC 2011), which include three organics (methylchlorophenoxypropionic acid [MCPP], tetrachloroethene [PCE], and trichloroethene [TCE]). HH RBCs were based on the methods used in the HHRA, presented as Appendix T of the RI report (CSC 2011), for evaluating commercial/industrial worker exposures. The HH RBCs represent the concentrations of chemicals in the relevant environmental media (e.g., soil) that would be consistent with a target risk or hazard level under conservative (i.e., protective) exposure conditions and thus are considered safe for current and future commercial/industrial workers.

3.1 Conclusions of the Human Health Risk Assessment

The HHRA was prepared to evaluate potential baseline health risks associated with chemicals present in soil, sediment, soil vapor, and surface water at the site. The results of the HHRA were used to identify chemicals and exposure media that may pose an unacceptable risk to current and/or future receptors at the site and to provide information for remedial planning.

The COCs that were evaluated included inorganics, polychlorinated biphenyls (PCBs), dioxins, herbicides/pesticides, polycyclic aromatic hydrocarbons (PAHs), semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs). Potential exposure scenarios that were considered include inhalation of indoor air and outdoor air vapors, inhalation of particulates, dermal contact with surface water, and exposure via direct contact to soils and sediment.

For on-site soils, the Former Ponds and Pads and Liquid Treatment study areas exhibited elevated risk estimates for commercial/industrial worker exposures and the Burial Trench, Central Drainage, and Former Ponds and Pads study areas exhibited elevated risk estimates from potential exposures due to the transport of on-site soil contamination via windborne vapors. MCPP was the primary risk driver for the Liquid Treatment study area, PCE was the primary risk driver for the Central Drainage and Former Ponds and Pads study areas, and TCE was the primary risk driver for the Burial Trench area. These chemicals are present at elevated concentrations in localized areas within the respective study areas. The sample locations that contributed the majority to the risk estimates were RISBON-37, RISBON-41 and RISBON-63 in the Former Ponds and Pads study area just south of the PSCT, RISBLT-02 in the Liquid Treatment study area, RISBCD-07 in the Central Drainage study area and RISSBC-05 in the Burial Trench study area.

Based on the conclusions of the HHRA, the following COCs were considered RDCs for human receptors:

- MCPP
- PCE
- TCE

3.2 Human Health Risk-based Concentration Calculation Methodology

Deriving RBCs for the RDCs in soil requires information regarding the level of human intake of the RDCs (exposure assessment), the relationship between intake of the RDCs and its toxicity (toxicity assessment), and the acceptable target risk. RBCs for soil were derived using the same exposure algorithms, exposure assumptions, and methods that were used to estimate cancer risk and noncancer hazard as presented in the HHRA (CSC 2011) and are based principally on guidelines provided by the USEPA (1991, 2002) and Cal-EPA (1992, 1999).

For site chemicals classified as carcinogens, a target risk of 1 x 10^{-5} was used to derive HH RBCs for the purposes of the FS data evaluation. This target risk level is the mid-point of the National Contingency Plan (NCP) discretionary risk range of 1 x 10^{-6} to 1 x 10^{-4} used to evaluate risks at Superfund sites. The use of this risk level does not imply this level of protectiveness will be used by the USEPA in the final remedy. For chemicals classified as noncarcinogens, a hazard quotient of 1 was used. The exposure assumptions and toxicity values used in the HH RBC derivation are described in detail in Appendix T of the RI report (CSC 2011) and are presented in Attachment J-2.

The following subsections present the equations that were used along with the input parameters presented in Attachment J-2 to derive the HH RBCs.

3.2.1 RBCs for Soil: Cancer Health Effects

The RBC equation below describes the relationship between RBC, estimated intake, toxicity, and target risk for cancer health effects (USEPA, 1991, 2002).

$$\text{soil RBC}_C = \frac{TR}{\left[\left(CSF_{oral}\right)\times\left(LADD_{oral}+LADD_{dermal}\right)\right]+\left(CSF_{inh}\times LADD_{inh}\right)}$$

Where:

soil RBC_C = risk-based concentration for soil based on cancer effects (mg/kg);

TR = target cancer risk level (unitless);

CSF_{oral} = cancer slope factor for oral (ingestion and dermal-contact) exposures $(mg/kg\cdot d)^{-1}$;

$LADD_{oral}$ = intake factor, lifetime average daily dose for ingestion (kg soil per kg body weight per day);

$LADD_{dermal}$ = intake factor, lifetime average daily dose for dermal contact (kg soil per kg body weight per day);

CSF_{inh} = cancer slope factor for inhalation exposures $(mg/kg\cdot d)^{-1}$; and

$LADD_{inh}$ = intake factor, lifetime average daily dose for inhalation (kg soil per kg body weight per day).

The equations used to estimate the lifetime average daily dose (LADD) for carcinogens were presented in Section 3.3 of the HHRA, presented as Appendix T of the RI report (CSC 2011) and are presented in Attachment J-2.

3.2.2 RBCs for Soil: Noncancer Health Effects

The RBC equation below describes the relationship between RBC, estimated intake, toxicity, and target hazard for noncancer health effects (USEPA, 1991, 2002).

$$\text{soil RBC}_{\text{NC}} = \frac{\text{THI}}{\left(\frac{\text{ADD}_{\text{oral}}}{\text{RfD}_{\text{oral}}}\right) + \left(\frac{\text{ADD}_{\text{dermal}}}{\text{RfD}_{\text{oral}}}\right) + \left(\frac{\text{ADD}_{\text{inh}}}{\text{RfD}_{\text{inh}}}\right)}$$

Where:

soil RBC_{NC}	=	risk-based concentration for soil based on noncancer effects (mg/kg);
THI	=	target noncancer hazard index (unitless);
RfD_{oral}	=	noncancer reference dose for oral (ingestion and direct-contact) exposures (mg/kg·d);
ADD_{oral}	=	intake factor, average daily dose for ingestion (kg soil per kg body weight per day);
$\text{ADD}_{\text{dermal}}$	=	intake factor, average daily dose for dermal contact (kg soil per kg body weight per day);
RfD_{inh}	=	noncancer reference dose for inhalation exposure (mg/kg·d); and
ADD_{inh}	=	intake factor, average daily dose for inhalation (kg soil per kg body weight per day).

The equations used to estimate the average daily dose (ADD) for noncarcinogens were presented in Section 3.3 of the HHRA, presented as Appendix T of the RI report (CSC 2011) and are presented in Attachment J-2.

3.3 Summary of Human Health Risk-based Concentrations

The HH RBCs for commercial/industrial workers potentially exposed to soil in the study areas with no planned remedy are presented in Table J-2. The lowest of the RBCs based on cancer or noncancer effects was selected as the Human Health Site-Specific Soil Threshold Level to define remedial alternatives and specify impacted locations or areas for remedial evaluation and are highlighted in blue in Table J-2. These HH RBCs are considered protective of current and future commercial/industrial workers exposure to surface and shallow soil at the site.

It should be noted that while there may be a few individual samples in a study area that exceed a RBC, the study area as a whole may not pose a significant risk due to the use of the 95 percent Upper Confidence Limit (UCL) of the mean concentration in the HHRA. The 95 percent

UCL statistical analysis was used to define a risk-based cleanup approach across a study area because it better represents the concentration a receptor may be exposed to on a regular basis.

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Table J-1
Ecological Risk-Driving Chemicals and Risk-Based Concentrations in Soil
Casmalia Resources Superfund Site Feasibility Study

	Terrestrial Invertivorous Mammal				Terrestrial Herbivorous Mammal				Terrestrial Carnivorous Mammal				Terrestrial Invertivorous Bird			
	Ornate Shrew				California Vole				Striped Skunk				Western Meadowlark			
Risk-Driving Chemicals[1]	Highest LOAEL/high TRV-based HQ	Study Area	Surface and shallow soil EPC (0-5.5 ft bgs; mg/kg)	RBC[2]	Highest LOAEL/high TRV-based HQ	Study Area	Surface and shallow soil EPC (0-5.5 ft bgs; mg/kg)	RBC[2]	Highest LOAEL/high TRV-based HQ	Study Area	Surface and shallow soil EPC (0-5.5 ft bgs; mg/kg)	RBC[2]	Highest LOAEL/high TRV-based HQ	Study Area	Surface soil EPC (0-0.5 bgs; mg/kg)	RBC[2]
Chromium	1.0	West Canyon Spray Area	206	204	0.1	West Canyon Spray Area	206	1442	0.1	West Canyon Spray Area	206	1825.4	8.0	West Canyon Spray Area	590.6	74
Copper	20.0	West Canyon Spray Area	271	14	2.5	West Canyon Spray Area	271	107	1.9	West Canyon Spray Area	271	143.1	18.1	West Canyon Spray Area	461.0	25
Zinc	0.5	RCRA Canyon	176	353	0.1	RCRA Canyon	176	3067	0.1	RCRA Canyon	176	2944.8	1.5	RCRA Canyon	292.9	191

	Terrestrial Herbivorous Bird				Terrestrial Carnivorous Bird				Terrestrial Plants[3]				Soil invertebrates[2]			
	Western Meadowlark				American Kestrel											
Risk-Driving Chemicals[1]	Highest LOAEL/high TRV-based HQ	Study Area	Surface soil EPC (0-0.5 bgs; mg/kg)	RBC[2]	Highest LOAEL/high TRV-based HQ	Study Area	Surface soil EPC (0-0.5 bgs; mg/kg)	RBC[2]	Highest HQ	Study Area	Surface and shallow soil EPC (0-5.5 ft bgs; mg/kg)	RBC[2]	Highest HQ	Study Area	Surface soil EPC (0-0.5 bgs; mg/kg)	RBC[2]
Chromium	7.6	West Canyon Spray Area	591	78	0.8	West Canyon Spray Area	591	724	206.3	West Canyon Spray Area	206	1.0	1477	West Canyon Spray Area	591	0.4
Copper	6.6	West Canyon Spray Area	461	70	8.1	West Canyon Spray Area	461	57	3.9	West Canyon Spray Area	271	70	6	West Canyon Spray Area	461	80
Zinc	0.4	RCRA Canyon	293	667	0.8	RCRA Canyon	293	358	3.5	RCRA Canyon	176	50	2.9	RCRA Canyon	293	100

Notes:
(blue) Selected surface and shallow soil ecological risk-based concentration for 0-5.5 feet bgs interval.
(green) Selected surface soil ecological risk-based concentration for 0-0.5 foot bgs interval.
bgs = below ground surface
EPC = exposure point concentration; based on the 95% upper confidence limit (UCL) of the mean or maximum detected concentration (presented in Attachments 5 and 5A of Appendix U of the ERA (CSC 2011).
ERA = ecological risk assessment
HQ = hazard quotient (unitless)
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
Eco RBC = ecological risk-based concentration
NA = not applicable
TRV = toxicity reference value
1. Ecological RBCs identified based on the results of the ERA (CSC 2011) and were not derived for the American badger as the risk-driving chemicals were not detected in deep soils (5.5-10 feet bgs).
2. Wildlife Eco RBCs derived using Tier 2 ERA data, and plant and soil invertebrate Eco RBCs derived using Tier 1 ERA data.

Reference:
Casmalia Steering Committee (CSC). 2011. Final Remedial Investigation Report. January.

Table J-2
Human Health Risk-Driving Chemicals and Risk-Based Concentrations in Soil
Commercial/Industrial Worker
Casmalia Resources Superfund Site Feasibility Study

Risk-Driving Chemicals	HH RBC (mg/kg) Target Risk = 1 x 10^{-5}	HH RBC (mg/kg) Target Hazard Quotient = 1
Organics		
MCPP	NA	770
TCE	50	76
PCE	11	120

[shaded] Selected surface and shallow soil (0 to 5.5 feet bgs) risk-based concentration (RBC)

bgs - below ground surface
HH RBC - human health risk-based concentration
mg/kg - milligram per kilogram
NA - not applicable

ATTACHMENT J-1

Input Parameters for Eco RBC Calculations

from the Ecological Risk Assessment (CSC 2011)

LIST OF TABLES

Attachment J-1, Table J-1.
Exposure Parameters for Terrestrial Wildlife

Parameter	Ornate Shrew		Source	California Vole		Source	Striped Skunk		Source	American Badger		Source
Composition of Diet (percent) [a]	Assumed	Actual		Assumed	Actual		Assumed	Actual		Assumed	Actual	
Soil	13	NA	Based on short-tailed shrew; Sample and Suter, 1994	2.4	NA	Based on meadow vole; Beyer et al., 1994	9	NA	Based on raccoon; Beyer et al., 1994	9	NA	Beyer et al., 1994
Invertebrates	100	94.6	Calculated based on main food item in short-talied shrew diet; USEPA, 1993.	0	0	Cal/EPA, 2007	0	30	Cal/EPA, 2007	0	0	--
Mammals	0	0	--	0	0	Cal/EPA, 2007	100	25	Cal/EPA, 2007	100	100	Sovada et al., 1999
Other	0	5.4	Based on composition of plant in diet of short-tailed shrew; USEPA, 1993	100	99.2	Based on composition of plant in diet; Cal/EPA, 2007	0	45	Cal/EPA, 2007	0	0	--
Body Weight (kg)	Juveniles	Adults		Juveniles	Adults		Juveniles	Adults		Juveniles	Adults	
	0.00210	0.00568	Mean body weight; Cal/EPA, 2007	<0.025	0.0253	Only value for juvenile body weight; For adults, mean body weight; Cal/EPA, 2007	1.6	1.7	Median (juvenile) and 5th percentile (adult); USEPA, 1993	4	6.4	Silva and Downing, 1995; Wright,
Food Ingestion Rate - Total	Juveniles	Adults		Juveniles	Adults		Juveniles	Adults				
% Moisture in Food	71	71	Based on average terrestrial invertebrate diet; USEPA, 1993	38	38	Based on average terrestrial plant diet; USEPA, 1993	68	68	Based on average terrestrial invertebrate diet; USEPA, 1993	68	68	Based on average mammalian diet; USEPA, 1993
kg/day (dw)	0.00059	0.00110	Allometric equation; Nagy, 2001 (eq. 31)	NA	0.00404	Allometric equation; Nagy, 2001 (eq. 11)	0.060	0.063	Allometric equation; Nagy, 2001 (eq. 9)	0.865	1.298	Allometric equation; Nagy, 2001 (eq. 9)
kg/kg body weight-day (dw)	0.282	0.194	Calculated	NA	0.160	Calculated	0.0374	0.0371	Calculated	0.216	0.203	For juveniles, calculated from kg/day (dw)
kg/kg body weight-day (ww)	0.85365	0.58625	Allometric equation; Nagy, 2001 (eq. 32)	NA	0.37903	Allometric equation; Nagy, 2001 (eq. 12)	0.12297	0.12192	Allometric equation; Nagy, 2001 (eq. 10)	0.758	0.709	Allometric equation; Nagy, 2001 (eq. 10)
Food Ingestion Rate (kg/kg body weight-day) [a]	Juveniles	Adults		Juveniles	Adults		Juveniles	Adults				
Soil (dw)	0.0366	0.0252	Calculated	--	0.00384	Calculated	0.00337	0.00334	Calculated	0.0195	0.0182	Calculated
Invertebrates (dw)	0.282	0.194	Calculated	--	--		--	--	--	--	--	--
Mammals (dw)	--	--	--	--	--		0.037	0.037	Calculated	0.216	0.203	Calculated
Plant diet: (dw) [b]	--	--	--	--	0.159	Calculated	--	--	--	--	--	--
Drinking Water Ingestion	Juveniles	Adults		Juveniles	Adults		Juveniles	Adults				
L/day	0.000385	0.000942	Allometric equation; USEPA, 1993	NA	0.00361	Allometric equation; USEPA, 1993	0.151	0.160	Allometric equation; USEPA, 1993	0.344738	0.526256	Allometric equation; USEPA, 1993
L/kg body weight-day	0.183	0.166	Calculated	NA	0.143	Calculated	0.0945	0.0939	Calculated	0.086	0.082	Calculated
Home Range (acres) [c]												
Lower bound	NA	0.0740	Based on short-tailed shrew; USEPA, 1993	NA	0.250	Zeiner et al., 1990	NA	598	Cal/EPA, 2007	NA	395.2	Messick 1981
								13.0	Based on raccoon; USEPA, 1993			
Upper bound	NA	4.40	Based on short-tailed shrew; USEPA, 1993	NA	2.50	Zeiner et al., 1990	NA	761	Cal/EPA, 2007	NA	592.8	Messick 1981
								12,222	Based on raccoon; USEPA, 1993			

Attachment J-1, Table J-1.
Exposure Parameters for Terrestrial Wildlife

Parameter	Western Meadowlark		Source	American Kestrel		Source
Composition of Diet (percent) [a]	Assumed	Actual		Assumed	Actual	
Soil	10	NA	Based on American woodcock; Beyer et al., 1994	1	NA	Based on American bald eagle; Pascoe et al., 1996
Invertebrates	100	60	Cal/EPA, 2007	0	40	Cal/EPA, 2007
Mammals	0	0	Cal/EPA, 2007	100	50	Cal/EPA, 2007
Other	0	30	Cal/EPA, 2007	0	10	Cal/EPA, 2007
Body Weight (kg)	Juveniles	Adults		Juveniles	Adults	
	0.00780	0.102	Only value (juvenile); median (adults); Cal/EPA, 2007	0.0751	0.0837	5th percentile; Cal/EPA, 1999
Food Ingestion Rate - Total	Juveniles	Adults		Juveniles	Adults	
% Moisture in Food	71	71	Based on average terrestrial invertebrate diet; USEPA, 1993	68	68	Based on average mammalian diet; USEPA, 1993
kg/day (dw)	0.00256	0.0148	Allometric equation; Nagy, 2001 (eq. 37)	0.015	0.016	Allometric equation; Nagy, 2001 (eq. 63)
kg/kg body weight-day (dw)	0.329	0.146	Calculated	0.1981	0.1910	Calculated
kg/kg body weight-day (ww)	1.08753	0.39673	Allometric equation; Nagy, 2001 (eq. 38)	0.71726	0.69167	Allometric equation; Nagy, 2001 (eq. 64)
Food Ingestion Rate (kg/kg body weight-day) [a]	Juveniles	Adults		Juveniles	Adults	
Soil (dw)	0.0329	0.0146	Calculated	0.001981	0.001910	Calculated
Invertebrates (dw)	0.329	0.146	Calculated	--	--	--
Mammals (dw)	--	--	--	0.198	0.191	Calculated
Plant diet: (dw) [b]	0.329	0.146	Calculated	--	--	--
Drinking Water Ingestion	Juveniles	Adults		Juveniles	Adults	
L/day	0.00228	0.0127	Allometric equation; USEPA, 1993	0.0104	0.0112	Allometric equation; USEPA, 1993
L/kg body weight-day	0.293	0.126	Calculated	0.139	0.134	Calculated
Home Range (acres) [c]						
Lower bound	NA	10.0	Cal/EPA, 2007	NA	269	Cal/EPA, 2007
		0.740	Based on American woodcock; USEPA, 1993		24.0	USEPA, 1993
Upper bound	NA	32.0	Cal/EPA, 2007	NA	1,117	Zeiner et al., 1990
		423	Based on American woodcock; USEPA, 1993		1,236	USEPA, 1993

Attachment J-1, Table J-1.
Exposure Parameters for Terrestrial Wildlife

kg	Kilograms.
L	Liters.
dw	Dry weight.
ww	Wet weight.
NA	Not available

[a] Assumed that diet consists of 100% of the most contaminated food item for ingestion calculations.

[b] Based on data for raccoon.

[c] Based on data for American woodcock.

[d] Bald eagle used as surrogate species based on feeding habit.

[e] The western meadowlark, which ingest both plants and invertebrates, will be evaluated under two scenarios in Tier 1. Scenario 1 assumes a diet of invertebrates only and Scenario 2 assumes a diet of plants only, to allow evaluation of both herbivorous and insectivorous receptors.

[f] Includes home range, foraging range, and territory size.

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Attachment J-1, Table J-2a
Soil-to-Plant Bioaccumulation Factors

CPECs in Soil	log K_{ow} [a]	K_{oc} [a,i]	Soil-to-Plant Uptake BAF_{plant} (dw) (unitless)	Primary Reference	Secondary Reference
Chromium	--	--	0.0410	Bechtel Jacobs, 1998a	USEPA, 2007
Copper	--	--	ln(Cp) = 0.394 * ln(Cs) + 0.668	Bechtel Jacobs, 1998a	USEPA, 2007
Zinc	--	--	ln(Cp) = 0.554 * ln(Cs) + 1.575	Bechtel Jacobs, 1998a	USEPA, 2007

From Appendix U of the Final Remedial Investigation (RI) Report (CSC 2012); only showing values for the risk drivers.
Footnotes after Table J-2c (includes all footnotes presented in the original tables in Appendix U of the Final RI [CSC 2012]).

Attachment J-1, Table J-2b.
Soil-to-Invertebrate Bioaccumulation Factors

CPECs in Soil	log K_{ow} [a]	K_{oc} [a,i]	Soil-to-Invertebrate Uptake BAF_{inv} (dw) (unitless)	Primary Reference	Secondary Reference
Chromium	--	--	0.306	Sample et al., 1999	USEPA, 2007
Copper	--	--	0.515	Sample et al., 1999	USEPA, 2007
Zinc	--	--	$\ln(Ci) = 0.328 * \ln(Cs) + 4.449$	Sample et al., 1999	USEPA, 2007

From Appendix U of the Final Remedial Investigation (RI) Report (CSC 2012); only showing values for the risk drivers.

Footnotes after Table U-13c (includes all footnotes presented in the original tables in Appendix U of the Final RI [CSC 2012]).

Attachment J-1, Table J-2c.
Soil-to-Mammal Bioaccumulation Factors

CPECs in Soil	log K_{ow} [a]	K_{oc} [a,i]	Soil-to-Mammal Uptake BAF_{mam} (dw) (unitless)	Primary Reference	Secondary Reference
Chromium	--	--	ln(Cm) = 0.7338 * ln(Cs) - 1.4599	Sample et al., 1998b	USEPA, 2007
Copper	--	--	ln(Cm) = 0.1444 * ln(Cs) + 2.042	Sample et al., 1998b	USEPA, 2007
Zinc	--	--	ln(Cm) = 0.0706 * ln(Cs) + 4.3632	Sample et al., 1998b	USEPA, 2007

From Appendix U of the Final Remedial Investigation (RI) Report (CSC 2012); only showing values for the risk drivers.
Footnotes after Table J-2c (includes all footnotes presented in the original tables in Appendix U of the Final RI [CSC 2012]).

Attachment J-1, Table J-2c.
Footnotes for Bioaccumulation Factors

[--] Not applicable.
[BAF] Bioaccumulation factor (unitless):
inv = soil-to-invertebrates.
plants = soil-to-plants.
mam = soil-to-mammals.
[BCF] Bioconcentration factor (unitless)
[CPEC] Chemical of potential ecological concern.
[dw] Dry weight.
[NA] Not available.
[TEQ] Toxic equivalent quotient.
[a] Sources for octanol-partitioning coefficient (log Kow) and water-organic carbon partitioning coefficient (Koc):
1 SRC database (2007).
2 Hazardous Substance Data Bank (2007).
3 Appendix 4-1 (USEPA, 2007) of EcoSSL Guidance (USEPA, 2007)
[b] These chemicals do not bioaccumulate in biota in accordance with USEPA (2007); VOCs and other chemicals with low log Kow (<3.5) do not bioaccumulate (USEPA, 2000); therefore, BAFs for these chemicals = 0.
[c] PAHs metabolize rapidly in wildlife (USEPA, 2007); therefore soil-to-wildlife BAF = 0 for PAHs.
[d] TCDD used as surrogate.
[e] Mean of inorganic empirical data of the metal CPECs identified in soil or sediment at the Site.
[f] Dieldrin used as a surrogate.
[g] Both the alpha and delta isomers were detected onsite. BAF data for the alpha-BHC is presented because plant and invertebrate BAFs were higher for this isomer. No data were available for the technical BHC mixture.
[h] Based on regression for all non-ionic contaminants (USEPA, 2007): log (BAF) = -0.4057 * (log Kow) + 1.781
[i] Only for CPECs where the Jager method was applied.
[j] Values for salt-marsh harvest mouse for uptake from plants (most conservative) based on Aroclor 1254.
[k] Nickel uptake to earthworms can not be accurately predicted with a regression model or BAF.
[l] Based on Travis and Arms (1988) model for uptake from soil-to-plants or from prey-to-mammals (see text).
[m] Aroclor 1260 used as a surrogate.
[n] BSAFs for total organochlorine pesticides (N=107) used.
[o] Endosulfan sulfate used as surrogate.
[p] Arochlor 1254 used as surrogate.
[q] Total PAH BSAF used due to lack of data.
[r] Calculated using equation (Southworth et.al., 1978): log(BCF) = 0.819 * logKow - 1.146

Attachment J-1, Table J-2c.
Footnotes for Bioaccumulation Factors

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Attachment J-1, Table **J-3**.

Summary of Toxicity Reference Values for Widlife

	Toxicity Reference Values for Mammals (mg/kg-day) [c]													
	CSC Proposed Mammal TRVs[g]										BTAG Mammal TRVs[h, z]			
CPEC	Low TRV	Species	Endpoint	Sources		High TRV	Species	Endpoint	Sources (primary; secondary)		Low TRV	Sources (primary)	High TRV	Sources (primary)
Chromium	2.4	-	REP, GRO	Geomean; USEPA, 2007	a	9.62	-	REP, GRO	Geomean; USEPA, 2007	a, g	-	-	-	-
Copper	5.6	Pig (*Sus scrofa*)	GRO, MOR	Allcroft et al, 1961; USEPA, 2007	a	9.34	Pig (Sus scrofa)	GRO, MOR	Allcroft et al, 1961; USEPA, 2007	a, g	2.67	Pocino & others 1991	632	Hebert & others 1993
Zinc	9.61	-	-	Aughey & others 1977; CalEPA, 2002	z	411.43	-	-	Shlicker & Cox 1968; CalEPA, 2002	z	9.61	Aughey & others 1977	411.43	Shlicker & Cox 1968

Attachment J-1, Table **J-3**.

Summary of Toxicity Reference Values for Widlife

CPEC	Toxicity Reference Values for Birs (mg/kg-day)[c]													
	CSC Proposed Bird TRVs[g]										Bird BTAG TRVs[h, z]			
	Low TRV	Species	Endpoint	Sources (primary; secondary)		High TRV	Species	Endpoint	Sources (primary; secondary)		Low TRV	Sources (primary)	High TRV	Sources (primary)
Chromium	2.66	-	REP, GRO	Geomean; USEPA, 2007	a	2.78	-	REP, GRO	Geomean; USEPA, 2007	a	-	-	-	-
Copper	4.05	Chicken (*Gallus domesticus*)	REP	Ankari et al, 1998; USEPA, 2007	a	12.1	Chicken (*Gallus domesticus*)	REP	Ankari et al, 1998; USEPA, 2007	a	2.3	Norvell & others 1975	52.3	Jensen & Maurice 1978
Zinc	17.2	-	-	Gasaway & Buss 1972; CalEPA, 2002	z	172	-	-	Gasaway & Buss 1972; CalEPA, 2002	z	17.2	Gasaway & Buss 1972	172	Gasaway & Buss 1972

Attachment J-1, Table J-3.
Summary of Toxicity Reference Values for Wildlife

Footnotes from original table presented in Appendix U of the Final Remedial Investigation (RI) Report (CSC 2012):

mg/kg-day	Milligrams per kilogram per day.
BERA	Baseline Ecological Risk Assessment
BTAG	Biological Technical Advisory Group.
CPEC	Chemicals of potential ecological concern.
Endpoints	REP = reproduction; GRO = growth; MOR = mortality
NA	Not applicable; TRVs required for badger exposed to deep soil only.
TRV	Toxicity reference value.
-	Not available.
[a]	From EcoSSL Guidnce (USEPA, 2007).
[b]	From ORNL Report (Sample et al., 1996).
[c]	Low TRVs are based on NOAEL and high TRVs are based on LOAEL.
[d]	Reported NOAEL values are used as the low TRV and the "Dose" (i.e., before uncertainty factors were applied) reported is used as the high TRV. Reported LOAEL values are used as the high TRV and a UF of 10 applied to calculate the low TRV. Note: some of the TRVs listed in this reference may not be appropriate.
[e]	Benzo(a)pyrene values used as surrogate for high molecular weight PAHs.
[f]	Naphthalene values used as surrogate for all low molecular weight PAHs.
[g]	derived for the BERA as described in Attachment 2
[h]	Navy/BTAG TRV workgroup selected biological effects that primarily related to growth, reproduction, and development; however, all effects deemed ecologically relevant were considered when developing TRVs.
[i]	Dibutyltin and tributyltin value used
[j]	Butanol used as a surrogate for TRV derivation.
[k]	Endosulfan used as surrogate for TRV derivation
[l]	N-nitrosodimethylamine used as surrogate
[m]	Di-n-butylphthalate values used as a surrogate
[n]	1,2-Dichloroethane value used as surrogate.
[o]	MCPA surrogate used.
[p]	2,4-DB surrogate used.
[q]	Benzene values used as surrogate.
[r]	Butanol used as a surrogate for TRV derivation.
[s]	Lindane (gamma-HCH) surrogate used.
[t]	A UF of 0.1 was applied to extrapolate a high TRV from the NOAEL-based TRV.
[u]	Acrylonitrile used as surrogate.
[v]	Based on 2,3,7,8-tetrachlorodibenzodioxin (TCDD).
[w]	Chlorobenzene used as surrogate.
[x]	MTBE used as surrogate.
[y]	Heptachlor used as surrogate
[z]	From CalEPA Guidance (CalEPA, 2002).

Attachment J-1, Table J-3.
Summary of Toxicity Reference Values for Wildlife

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Attachment J-1, Table **J-4**

Tier 2 Soil and Sediment Bioaccumulation Factors

CPEC	**CAS No.**	**Soil-to-Plant Uptake BAF_{plant} (ww) (unitless)**	**Soil-to-Invertebrate Uptake BAF_{inv} (ww) (unitless)**	**Soil-to-Mammal Uptake BAF_{mam} (ww) (unitless)**
Chromium	7440-47-3	0.00261	$\log(Ci) = 0.7917 * \log(Cs) - 1.7829$	0.00536
Copper	7440-50-8	0.129	0.406	0.295
Zinc	7440-66-6	0.207	0.796	0.668

ATTACHMENT J-2

Input Parameters for Human Health RBC Calculations from the Human Health Risk Assessment (CSC 2011)

LIST OF TABLES

ATTACHMENT J-2, TABLE J-1
EXPOSURE PARAMETERS: COMMERCIAL/INDUSTRIAL WORKER
VALUES USED FOR SOIL/SEDIMENT INTAKE CALCULATIONS

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	Intake Equations
General Parameters	Cs	Chemical Concentration in Soil/Sediment	mg/kg	chem-specific	--	
	EF	Exposure Frequency	days/year	250	USEPA 1991	
	ED	Exposure Duration	years	25	USEPA 1991	
	BW	Body Weight	kilograms	70	USEPA 1989	
	AT-C	Averaging Time (Cancer)	days	25,550	USEPA 1989	
	AT-N	Averaging Time (Noncancer)	days	ED x 365	USEPA 1989	
Incidental Ingestion	IR-S	Ingestion Rate of Soil/Sediment	mg/day	100	USEPA 1991	Chronic Daily Intake (mg/kg/day) =
	CF	Conversion Factor	kg/mg	1.0E-06	--	ADD or LADD = Cs x IR-S x EF x ED x CF x 1/BW x 1/AT
Dermal Contact	SA	Surface Area Available for Contact	cm^2/day	3,300	USEPA 2002	Chronic Daily Intake (mg/kg/day) =
	AF	Adherence Factor	mg/cm^2	0.2	USEPA 2002	ADD or LADD
	AbsD	Dermal Absorption	unitless	chem-specific	USEPA 2004b	= Cs x SA x EF x ED x AF x AbsD x CF x 1/BW x 1/AT
	CF	Conversion Factor	kg/mg	1.0E-06	--	
Outdoor Inhalation	Ca	Chemical Concentration in Air	mg/m^3	Cs / (PEF or VF)	USEPA 2002	Chronic Daily Intake (mg/kg/day) =
	IR-A	Inhalation Rate	m^3/day	10.8[a]	USEPA 1997	ADD or LADD
	PEF	Particulate Emission Factor	m^3/kg	1.1E+10	USEPA 2002	Outdoor = Cs x IR-A x EF x ED x (1/PEF or VF) x 1/BW x 1/AT
	VF	Volatilization Factor	m^3/kg	chem-specific	USEPA 2002	Indoor = Ca x IR-A x EF x ED x 1/BW x 1/AT

Notes na: not applicable; -- not available; LADD: lifetime average daily dose (carcinogens); ADD = average daily dose (noncarcinogens)

a) Value is the average inhalation rate for adult males and females performing a mixture of light and moderate activities during an 8-hour workday (see Table 5-16 in USEPA, 1997).

Sources: USEPA 1989. Risk Assessment Guidance for Superfund (RAGS). Volume I: Human Health Evaluation Manual (HHEM), Part A. OERR. EPA/540/1-89/002.

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ATTACHMENT J-2, TABLE J-2
CHRONIC TOXICITY CRITERIA

Chemical	Dermal Absorption from Soil, ABSd	Cancer Slope Factor, CSF $(mg/kg\text{-}day)^{-1}$				Chronic Noncancer Reference Dose, RfD (mg/kg-day)			
		Oral	Source	Inhalation	Source	Oral	Source	Inhalation	Source
Herbicides									
MCPP	0.05	NC	1	NC	1	1.0E-03	2	1.0E-03	2 b
VOCs									
Tetrachloroethylene	0.1	5.4E-01	1	2.1E-02	1	1.0E-02	2	1.0E-02	1 a
Trichloroethylene	0.1	1.3E-02	1	7.0E-03	1	3.0E-04	3 n	1.0E-02	3

Notes

ABSd: dermal absorption factor (USEPA, 2004b); RfD: reference dose; RfC: reference concentration; REL: reference exposure level

a - Value converted from an RfC value (units: mg chemical/m^3 air), assuming a 20 m^3/day inhalation rate and a 70 kg body weight.

b - Route-to-route extrapolation.

n - National Center for Environmental Assessment (NCEA) from Region IX PRG table (USEPA, 2004a)

Cancer Toxicity Value Reference Priority:

1. Cal-EPA OEHHA (2007), Toxicity Criteria Database http://www.oehha.ca.gov/risk/chemicalDB/index.asp
2. USEPA (2007) Integrated Risk Information System Database. URL: http://www.epa.gov/iriswebp/iris/subst/index.html
3. USEPA (2004a) Region IX Preliminary Remediation Goal (PRG) table

Noncancer Toxicity Value Reference Priority:

The lower value between the REL-to-RfD (1) or the RfD (2) was used for the inhalation noncancer toxicity criteria:

1. Cal-EPA OEHHA (2007), Chronic RELs for Airborne Toxicants, http://www.oehha.org/air/chronic_rels/AllChrels.html
2. USEPA (2007) Integrated Risk Information System Database. URL: http://www.epa.gov/iriswebp/iris/subst/index.html

ATTACHMENT J-2, TABLE J-3
VOLATILIZATION AND PARTICULATE EMISSION FACTORS

Parameter	Value	Units	Reference
Water-filled soil porosity (θw)	2.2E-01	(Lwater-Lsoil)	Default values for Silty Clay (SIC)
Total soil porosity (θ_T)	4.8E-01	(Lpore-Lsoil)	Default values for Silty Clay (SIC)
Air-filled soil porosity (θa)	2.7E-01	(Lair-Lsoil)	Default values for Silty Clay (SIC)
Soil bulk density (Pb)	1.38	g/cm^3	Default values for Silty Clay (SIC)
Fraction organic carbon in soil (foc)	0.002	unitless	Default (USEPA 2002)
Exposure interval (T), worker	7.9E+08	sec	25 year exposure duration
Inverse of mean conc, Q/C	41.21	(g/m^2-s per kg/m^3)	Calculated for a 10-acre site in Los Angeles (eqn E-2, USEPA 2002)
Fraction of vegetative cover, G	0.5	unitless	Default (USEPA 2002)
Mean annual windspeed (Um)	4.69	m/s	Default (USEPA 2002)
Equivalent threshold value of windspeed at 7m (Ut)	11.32	m/s	Default (USEPA 2002)
Function dependent on Um/Ut (Fx)	1.9E-01	unitless	Default (USEPA 2002)
Particulate Emission Factor, PEF	1.1E+10	(m3/kg)	Estimated for a 10-acre area

Note:

Particulate Emission Factor; PEF (USEPA 2002): PEF = $[(Q/C * 3600) / (0.036 * (1-G) * (Um/Ut)^3 * Fx)]$

Chemical	Diffusivity in Air (Dair)	Henry's Law Constant (H')	Diffusivity in Water (Dw)	Soil organic carbon partition coeff (Koc)	Soil-water partition coefficient (Kd)	Apparent Diffusivity (Da)	Worker VF (m^3/kg)
Tetrachloroethylene	7.2E-02	7.6E-01	8.2E-06	1.6E+02	3.1E-01	3.4E-03	1.3E+03
Trichloroethylene	7.9E-02	4.3E-01	9.1E-06	9.3E+01	1.9E-01	3.0E-03	1.4E+03

Notes:

Volatilization Factor; $VF_{commWindW}$ (USEPA 2002): VF = $Q/C * ((3.14 * Da * T)^{1/2} * 10^{-4})/(2 * Pb * Da))$

ATTACHMENT J-2, TABLE J-4

DERIVATION OF SOIL RBCs

Chemical of Potential Concern	Cs mg/kg	Route EPC Value mg/m^3	Based on Noncancer Effects: Toxicity Criteria: Oral/Dermal RfD mg/kg-day	Toxicity Criteria: Inhalation RfD mg/kg-day	Intake Factor: ADD_{oral} mg/kg-day	Intake Factor: ADD_{dermal} mg/kg-day	Intake Factor: ADD_{inh} mg/kg-day	**RBC_{NC} mg/kg**	Based on Cancer Effects: Toxicity Criteria: Oral CSF mg/kg-day^{-1}	Toxicity Criteria: Inhalation CSF mg/kg-day^{-1}	Intake Factor: $LADD_{oral}$ mg/kg-day	Intake Factor: $LADD_{dermal}$ mg/kg-day	Intake Factor: $LADD_{inh}$ mg/kg-day	**RBC_C mg/kg**
HERBICIDES														
MCPP	1.0E+00	9.3E-11	1.0E-03	1.0E-03	9.8E-07	3.2E-07	9.9E-12	**7.7E+02**	NC	NC	3.5E-07	1.2E-07	3.5E-12	**--**
VOCS														
Tetrachloroethylene	1.0E+00	7.8E-04	1.0E-02	1.0E-02	9.8E-07	6.5E-07	8.2E-05	**1.2E+02**	5.4E-01	2.1E-02	3.5E-07	2.3E-07	2.9E-05	**1.1E+01**
Trichloroethylene	1.0E+00	7.3E-04	3.0E-04	1.0E-02	9.8E-07	6.5E-07	7.8E-05	**7.6E+01**	1.3E-02	7.0E-03	3.5E-07	2.3E-07	2.8E-05	**5.0E+01**

Notes:

" -- " not applicable; " NA " not available; " NC " noncarcinogen; " RBC " risk-based concentration

$$\mathrm{ADD_{oral}\ or\ LADD_{oral}} = \frac{\mathrm{C_s \times IR_s \times ABS \times EF \times ED \times CF}}{\mathrm{BW \times AT}}$$

$$\mathrm{ADD_{dermal}\ or\ LADD_{dermal}} = \frac{\mathrm{C_s \times SA \times SAF \times EF \times ED \times CF \times ABS_d}}{\mathrm{BW \times AT}}$$

$$\mathrm{ADD_{inh}\ or\ LADD_{inh}} = \frac{\mathrm{C_{oa} \times IR_a \times ABS \times EF \times ED}}{\mathrm{BW \times AT}}$$

$$\mathrm{soil\ RBC_{NC}} = \frac{\mathrm{THI}}{\left(\frac{\mathrm{ADD_{oral}}}{\mathrm{RfD_{oral}}}\right) + \left(\frac{\mathrm{ADD_{dermal}}}{\mathrm{RfD_{oral}}}\right) + \left(\frac{\mathrm{ADD_{inh}}}{\mathrm{RfD_{inh}}}\right)}$$

$$\mathrm{soil\ RBC_C} = \frac{\mathrm{TR}}{\left[\left(\mathrm{CSF_{oral}}\right) \times \left(\mathrm{LADD_{oral} + LADD_{dermal}}\right)\right] + \left(\mathrm{CSF_{inh} \times LADD_{inh}}\right)}$$

ATTACHMENT J-2, TABLE J-5
SUMMARY OF HUMAN HEALTH SOIL RBCs
COMMERCIAL/INDUSTRIAL WORKER SCENARIO

Chemical of Potential Concern	Surface (0 - 0.5ft) and Shallow Soil (0 - 5ft)	
	RBC_{NC} mg/kg	**RBC_C mg/kg**
HERBICIDES		
MCPP	**7.7E+02**	**--**
VOCS		
Tetrachloroethylene	**1.2E+02**	**1.1E+01**
Trichloroethylene	**7.6E+01**	**5.0E+01**

Notes:

" -- " not applicable

" RBC_{NC} " risk-based concentration based on noncancer effects

" RBC_C " risk-based concentration based on cancer effects